REMARKS:

CORRECTED AMENDMENT OF CLAIMS

The Examiner has required correction of the amendment filed on December 6, 2003 to totally underline new claims **30-38**. The Applicant submits that the above amendment complies with this requirement. The Applicant further submits that 37 CFR 1.173 does not require a complete listing of all claims. Support for these claims in the original patent was set forth in the amendment of December 6, 2003.

CONCLUSION

The Applicant submits that the amendment adding claims **30-38** complies with 37 CFR 1.173(d).

Respectfully submitted,

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Date: June 13, 2005

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IN THE US PATENT AND TRADEMARK OFFICE

Application Number:	10/729,582
Reissue of U.S. Patent	6,328,482
Attorney Docket Number	AFC-002/RE
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Applicant:	Benjamin B. Jian
Application Title:	MULTILAYER OPTICAL FIBER COUPLER
Examiner:	Juliana K. Kang
Art Unit:	2874

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PRELIMINARY AMENDMENT

Commissioner of Patents and Trademarks
Washington, DC 20231

Sir:

In response to the Office Action of February 16, 2005, kindly amend the application as follows and consider the following remarks.

AMENDMENTS TO THE SPECIFICATION begin on page 2 of this paper.

AMENDMENTS TO THE CLAIMS begin on page 3 of this paper.

REMARKS begin on page 12 of this amendment.

AMENDMENTS TO THE SPECIFICATION

Kindly replace the paragraph beginning at column 2, line 59 and ending at column 3, line 8 with the following amended paragraph.

In order to overcome the limitations of prior art optical fiber couplers, the present invention provides a multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, including a first layer that has a fiber socket formed by [photolithographic] masking and etching to extend through said first layer, and a second layer bonded to the first layer. A multilayer optical fiber coupler is described that has a vertical through hole (a "fiber socket") in a first layer that precisely aligns an optical fiber with an optical focusing element formed in the second layer. A method for forming the fiber couplers is described herein that can advantageously utilize semiconductor processing techniques including photolithography and dry etching to fabricate the couplers. The precision of the fiber socket structure allows single mode optical fibers to be passively aligned, and is also useful for aligning multimode optical fibers.

Kindly replace the paragraph beginning at column 8, line 50 and ending at column 8, line 52 with the following amended paragraph.

FIG. [31] <u>3I</u> shows the first and second layer bonded together. In addition, FIG. [31] <u>3I</u> shows the AR coating 154 formed on the upper surface of the second layer 140 at the air interface.

AMENDMENTS TO THE CLAIMS

Kindly cancel claims **37** and **38**, amend claims **1**, **6**, **10**, **13**, **14**, **18-29**, **30**, **34** and **36** and add new claim **39** as shown in the listing of claims below. All pending claims are listed for the convenience of the Examiner.

LISITING OF CLAIMS

1. (amended) A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:
a first layer, said first layer defining a fiber socket formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;
a second layer bonded to said first layer;
said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and wherein said second layer has an index of refraction substantially equal to the index of refraction of the core of said optical fiber.

2. The optical fiber coupler of claim 1 wherein said optical fiber comprises a single mode optical fiber.

3. The optical fiber coupler of claim 1 wherein said first layer comprises substantially single-crystal silicon.

4. The optical fiber coupler of claim 1 wherein said second layer comprises silicon.

5. The optical fiber coupler of claim 1 wherein said second layer comprises glass.

6. (amended) A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:
a first layer, said first layer defining a fiber socket formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

an epoxy that fills the gap between the end face of the optical fiber and the adjacent portion of the second layer, said epoxy having an index of refraction that approximately matches the index of the optical fiber so that optical losses are reduced.

7. (amended) A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

an optical device integrated into said second layer.

8. The optical fiber coupler of claim 7 wherein said optical device comprises a VCSEL to provide an integrated fiber optic transmitter.

9. The optical fiber coupler of claim 7 wherein said optical device comprises a photodetector to provide an integrated fiber optic receiver.

10. (amended) A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer, wherein said second layer comprises an optical focusing element arranged to couple optical radiation with said optical fiber;

said optical fiber having an end section that extends through the fiber socket, said optical

fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

wherein said optical focusing element comprises a gradient-index lens.

11. The optical fiber coupler of claim 10 wherein said optical focusing element has a focal point for optical radiation from the optical device, said optical fiber includes a core and a cladding surrounding said core, and said focal point is approximately situated along the central axis of said fiber socket, so that the optical radiation is coupled into said core of said optical fiber.

12. The optical fiber coupler of claim 11 wherein said optical fiber comprises a single mode fiber.

13. (amended) A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer, wherein said second layer comprises an optical focusing element arranged to couple optical radiation with said optical fiber;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

wherein said optical focusing element comprises a diffractive lens.

14. (amended) A multilayer optical fiber coupler for coupling optical radiation between an optical device and an optical fiber, comprising:

a first layer, said first layer defining a fiber socket formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align said optical fiber therein;

a second layer bonded to said first layer;

said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein; and

a third layer bonded to said second layer, said third layer comprising an optical device.

15. The optical fiber coupler of claim 14 wherein said optical device comprises a VCSEL.

16. The optical fiber coupler of claim 14 wherein said second layer comprises an optical focusing element.

17. The optical fiber coupler of claim 14 wherein said third layer comprises an optical focusing element.

18. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;
affixing optical fibers into said fiber sockets;
forming a plurality of VCSELs in said second layer in a predetermined configuration corresponding to the configuration of said fiber sockets; and
aligning said first layer with said second layer so that said VCSELs are aligned with said fiber sockets, and then performing said step of bonding said first and second layers together to provide said composite wafer.

19. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;
affixing optical fibers into said fiber sockets;

forming a plurality of photodetectors in said second layer in a predetermined configuration corresponding to the configuration of said fiber sockets; and

aligning said first layer with said second layer so that said photodetectors are aligned with said fiber sockets, and then performing said step of bonding said first and second layers together to provide said composite wafer.

20. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;

dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets;

forming a plurality of optical focusing elements in said second layer in a predetermined configuration corresponding to the configuration of said fiber sockets; and

aligning said first layer with said second layer so that said optical focusing elements are aligned with said fiber sockets, and then performing said step of bonding said first and second layers together to provide said composite wafer.

21. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;

dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said step of forming said plurality of optical focusing elements comprises forming refractive lenses.

22. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;
affixing optical fibers into said fiber sockets; and
wherein said step of forming said plurality of optical focusing elements comprises forming diffractive lenses.

23. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;
affixing optical fibers into said fiber sockets; and
wherein said step of forming said plurality of optical focusing elements comprises forming gradient-index lenses.

24. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber

sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;

dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said second layer comprises an optical material that has an index of refraction substantially equal to the index of refraction of said optical fiber, and said step of affixing said optical fibers into said fiber sockets includes applying an epoxy that approximately matches the index of refraction of said optical fiber into the fiber sockets to fill the gap between adjacent sections of said second layer and said optical fiber.

25. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;

dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and

wherein said step of bonding said first and second layers comprises anodic bonding.

26. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;

dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and
wherein said step of bonding said first and second layers comprises epoxy bonding.

27. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;
affixing optical fibers into said fiber sockets; and
wherein said step of bonding said first and second layers comprises metal solder bonding.

28. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:
[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;
bonding said first layer to a second layer together to provide a composite wafer;
dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;
affixing optical fibers into said fiber sockets; and
wherein said dicing step comprises cutting partially through said composite wafer, then performing said affixing step to affix optical fibers to said fiber sockets, and then physically separating said composite wafer into chips, each of which comprises one or more optical couplers.

29. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber;

bonding said first layer to a second layer together to provide a composite wafer;

dicing said composite wafer into a plurality of chips, each chip including one or more fiber sockets;

affixing optical fibers into said fiber sockets; and

bonding a third layer that comprises an optical device to said second layer.

30. (amended) A multilayer optical fiber coupler, comprising:

a first layer, said first layer having one or more fiber sockets formed by [photolithographic] masking and deep reactive ion etching to extend through said first layer, said fiber socket sized to receive and align an optical fiber therein.

31. The optical fiber coupler of claim 30 wherein said one or more fiber sockets include two or more fiber sockets.

32. The optical fiber coupler of claim 30, further comprising a second layer affixed to said first layer.

33. The optical fiber coupler of claim 32 wherein said optical fiber has an end section that extends through said fiber socket.

34. (amended) A method for making a plurality of monolithic optical fiber couplers that align an optical fiber that have a predetermined diameter, comprising:

[photolithographically] masking and deep reactive ion etching a first layer to form a plurality of through holes through the first layer, thereby forming a plurality of cylindrical fiber sockets in a predetermined configuration, said fiber sockets having a diameter approximately equal to the diameter of the optical fiber.

35. The method of claim 34, further comprising affixing optical fibers into said fiber sockets.

36. The method of claim 34, further comprising dicing said first layer into a plurality of chips, said chip including one or more fiber sockets.

37. (cancel) The method of claim 34, further comprising affixing said first layer to a second layer together to provide a composite wafer.

38. (cancel) The method of claim 37, further comprising dicing said composite wafer into a plurality of chips, said chip including one or more fiber sockets.

39. The method of claim 36 further comprising affixing optical fibers into said fiber sockets.

REMARKS:

STATEMENT OF STATUS AND SUPPORT FOR ALL CHANGES TO THE CLAIMS

37 CFR 1.173(c)

The Applicant submits that all claims **1-39** are pending in this reissue application as of the date of this amendment.

Support for the amendments to claims **1, 6, 10, 13, 14, 18-29, 30** and **34** can be found in the specification at col. 3, lines 23-38 and at col. 6, lines 41-54. Support for newly added claim **39** can be found FIG. 3J and in original claims **19-29**.

CORRECTED DECLARATION

The Examiner has required correction of the declaration specifically stating the feature that applicant believes is not necessary for patentability.

"said optical fiber having an end section that extends through the fiber socket, said optical fiber terminating at an end face situated approximately adjacent to the second layer, said fiber socket aligning and positioning said optical fiber therein".

Applicant submits herewith a corrected declaration specifically setting for this feature.

CORRECTION OF PRELIMINARY AMENDMENT

The Examiner has requested correction of the preliminary amendment filed December 6, 2003. A separate paper is filed herewith correcting the preliminary amendment per the Examiner's request.

AMENDMENTS TO THE SPECIFICAITON

The Applicant has amended the specification to conform to amendments to the claim and to correct a minor typographical error. No new matter has been added with these amendments.

AMENDMENTS TO THE CLAIMS

Claims **1, 6, 10, 13, 14, 18-29, 30** and **34** have been amended to recite that the fiber sockets are formed by masking and deep reactive ion etching. The Applicant submits that the removal of the word "photolithographic" before "masking" is not a recapture, since this feature was not added during prosecution to overcome a rejection.

CLAIM REJECTIONS

35 USC 251.

The Examiner has rejected claims **30-38** as being an improper recapture of broadened claimed subject matter. The Applicant submits that there is no recapture. The Applicant submits that the broadening aspect present in claim **30** relates to features that were not surrendered during prosecution. Canceling or amending a claim in an effort to overcome a reference is not per se an admission by the applicant that the scope of the claim before the cancellation or amendment is unpatentable because other evidence in the prosecution history may indicate the contrary (see *in re Clement* 131 F.3d 1464, 45 USPQ2d 1161 (Fed. Cir. 1997)). It is established law in recapture cases that, "if an applicant amends a broad claim in an effort to distinguish a reference and obtain allowance, but promptly files a continuation application to continue to traverse the prior art rejections, circumstances would suggest that the applicant did not admit that broader claims were not patentable — assuming that the applicant does not ultimately abandon the continuation application because the examiner refuses to withdraw the rejections." (see footnote to *in re Clement*).

The Applicant submits that in the present case, claims 1-4, 11-14 and 21 in the original application (09/327,826) were rejected in an Office Action dated January 29, 2001. Claims 1, 11, 14 and 21 were cancelled <u>without prejudice</u> in an amendment dated May 29, 2001. On November 26, 2001, U.S. Patent Application 09/995,214 was filed as a continuation of Application 09/327,826. Claim 1 of application 09/995,214 was nearly identical to claim 1 of the parent application 09/327,826. Furthermore, claims 7, 8, 11, 14 and 15 of application 09/995,214 corresponded to claims 6, 7, 10, 13 and 14 of U.S. application 09/327,826. In addition, application 09/995,214 contained method claims 19-31 corresponding to claims 21-33 of application 09/327,826. U.S. Patent Application 09/995,214 issued as U.S. Patent 6,527,455 on March 4, 2003. The Applicant submits that documentary support for these facts can be found in the official file histories for US Patent Applications 09/327,826 and 09/995,214.

Thus, although claims 1, 11, 14 and 21 of application 09/327,826 were cancelled, the Applicant promptly filed a continuation application directed to these broad claims and did not ultimately abandon the continuation application. Because original claims 1, 4, 11 and 21 of application 09/327,826 were cancelled without prejudice and promptly pursued in a continuation application

that issued as a patent, the Applicant submits that the applicant never admitted that the original claims were not patentable. As such, there is no recapture with respect to claims **30-38**.

35 USC 102

Claims **30-33** were rejected under 35 USC 102(b) as being anticipated by US Patent 5,434,939 to Matsuda. Claims **30-35** and **37** were rejected as being anticipated by JP 06-138341 to Konishi et al. The Applicant traverses the rejections. Claims **30** and **34** as they presently stand recite that the fiber sockets are formed in the first layer by photolithographic masking and <u>deep reactive ion</u> etching. The Applicant submits that neither Matsuda nor Konishi recites such a feature. Instead Konishi teaches forming a hole in the single crystal plate 15 using anisotropic etching by EPW (ethylene diamine pyrocatechol solution). See paragraph 0015. Matsuda does not specify the etch process for forming the guiding holes 306 other than that the etch can easily be stopped at the bottom layer of lower mirror 303 by use of a preferential etchant (see col. 5, lines 27-42). As such, neither Matsuda nor Konshi anticipates the rejected claims.

35 USC 103

The Examiner has rejected claims **1-7** and **10-17** as being obvious over Konishi. Claims **7-9** were rejected as being obvious over Matsuda. Claims **18** and **19** were rejected as being unpatentable over Matsuda in further view of EP 0405620 A2 to Kakii. Claims **20-29**, **36** and **38** were rejected as being obvious over Konishi in further view of Kakii. The Applicant respectfully traverses the rejections. Claims **1, 6, 10, 13,** and **14** have been amended to recite that the fiber sockets are formed in the first layer by photolithographic masking and deep reactive ion etching. As set forth above, neither Konishi, nor Matsuda teaches such a feature. Furthermore, Kakii does not teach this feature either. Instead Kakii teaches forming optical fiber grooves on a top surface of a substrate (see abstract), e.g., by machining (see col. 7, lines 1-5) such as cutting with a V-shaped diamond wheel. Thus, neither Konishi, Matsuda nor Kakii, either alone or in combination, teaches all the features of the rejected claims and a prima facie case of obviousness is not present. Furthermore, the use of deep reactive ion etching to form fiber sockets satisfies a long felt need in the art for passive alignment of optical fibers. This long felt need is discussed in the specification at col. 1, lines 31-45 and col. 2, lines 10-28. Deep reactive ion etching is characterized by high etch selectivity, high etch rate, and small vertical variation in hole diameter. These features facilitate formation of fiber sockets with sufficient precision for passive

alignment of single mode fibers (see col. 3, lines 23-38). Thus, without deep reactive ion etching, holes will not have the necessary precision for single-mode fiber passive alignment.

Therefore, for the reasons set forth above, the rejected claims are believed to distinguish over the cited art, either in their own right or by virtue of their dependence on allowable claims. Furthermore new claim **39** is believed to be allowable by virtue of its dependence on claim **34**.

CONCLUSION

The Applicant submits that all claims are allowable over the prior art and define an invention suitable for patent protection. Furthermore, none of the claims is broadened in a way that presents an impermissible recapture of subject matter surrendered during prosecution. The Applicants therefore respectfully request that the Examiner enter the amendment, consider the application, and point out the allowable subject matter in the next Office Action.

Respectfully submitted,

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